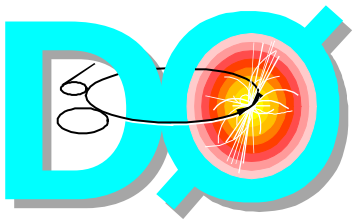
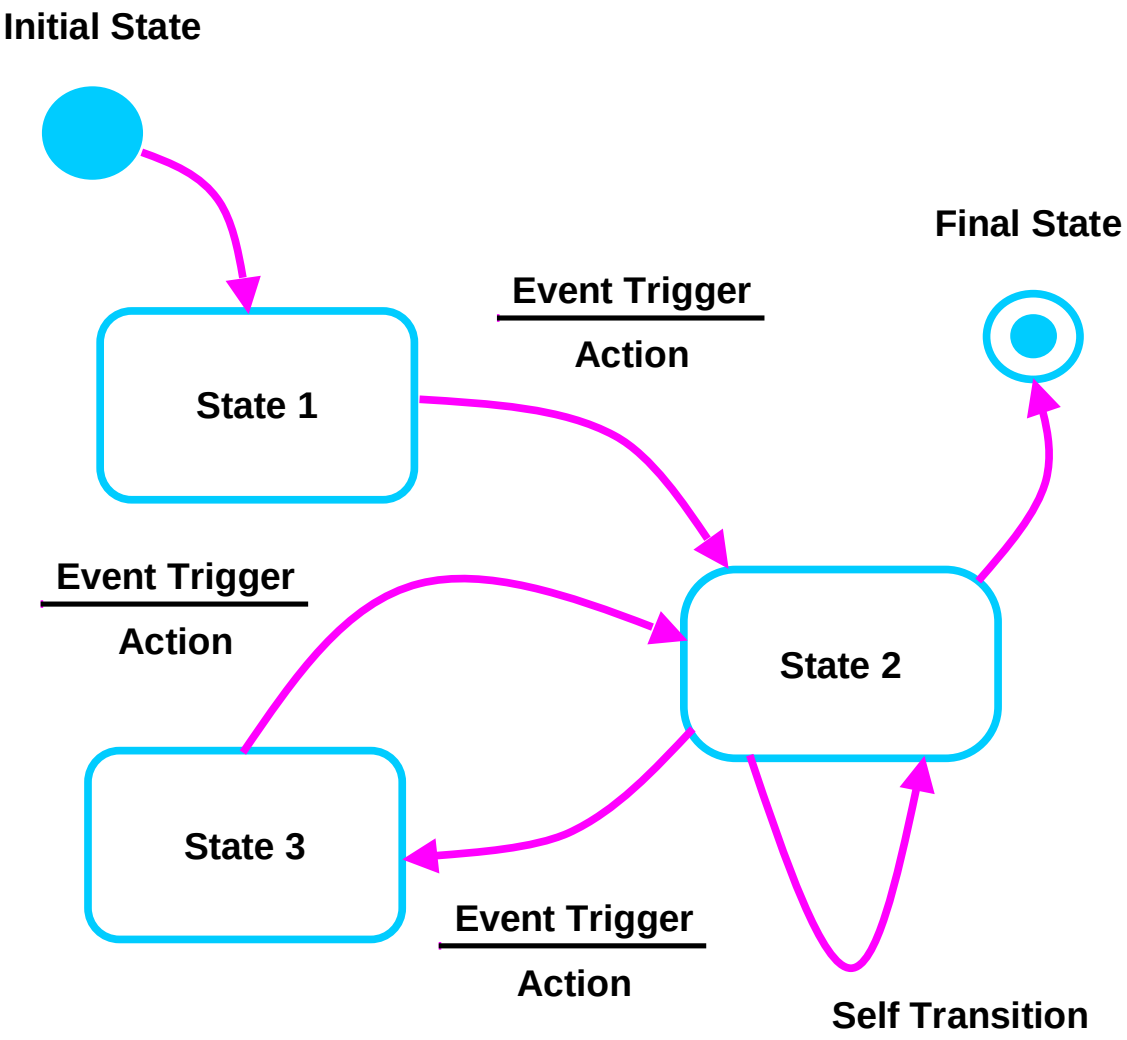
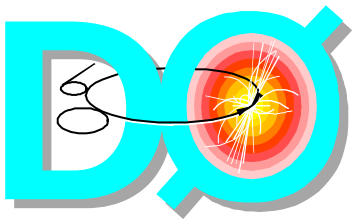


UML State Diagrams

A Simple State Machine

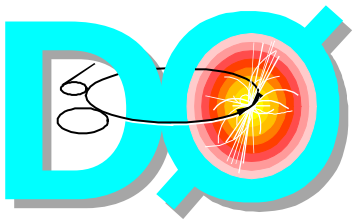




Definitions

- **State Machine**

  A *state machine* is a behavior which specifies the sequence of states an object visits during its lifetime in response to events, together with its responses to those events



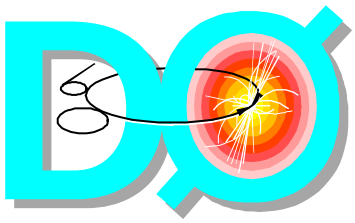
Definitions

- **State**

  A *state* is a condition during the life of an object during which it satisfies some condition, performs some activity, or waits for some external event

- **Event**

  An *event* is the specification of a significant occurrence. For a state machine, an event is the occurrence of a stimulus that can trigger a state transition

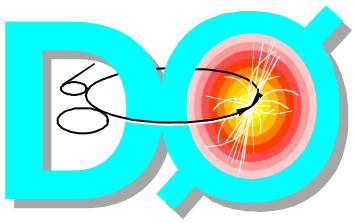


Definitions

- **Transition**

  A *transition* is a relationship between two states indicating that an object in the first state will, when a specified set of events and conditions are satisfied, perform certain actions and enter the second state. A transition has:

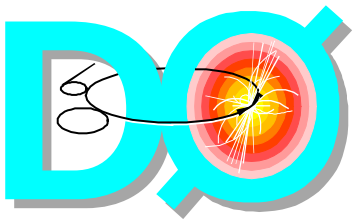
- **Transition Components**
  - **a source state**
  - **an event trigger**
  - **an action**
  - **a target state**



Definitions

- **Self-Transition**

  A *self-transition* is a transition whose source and target states are the same

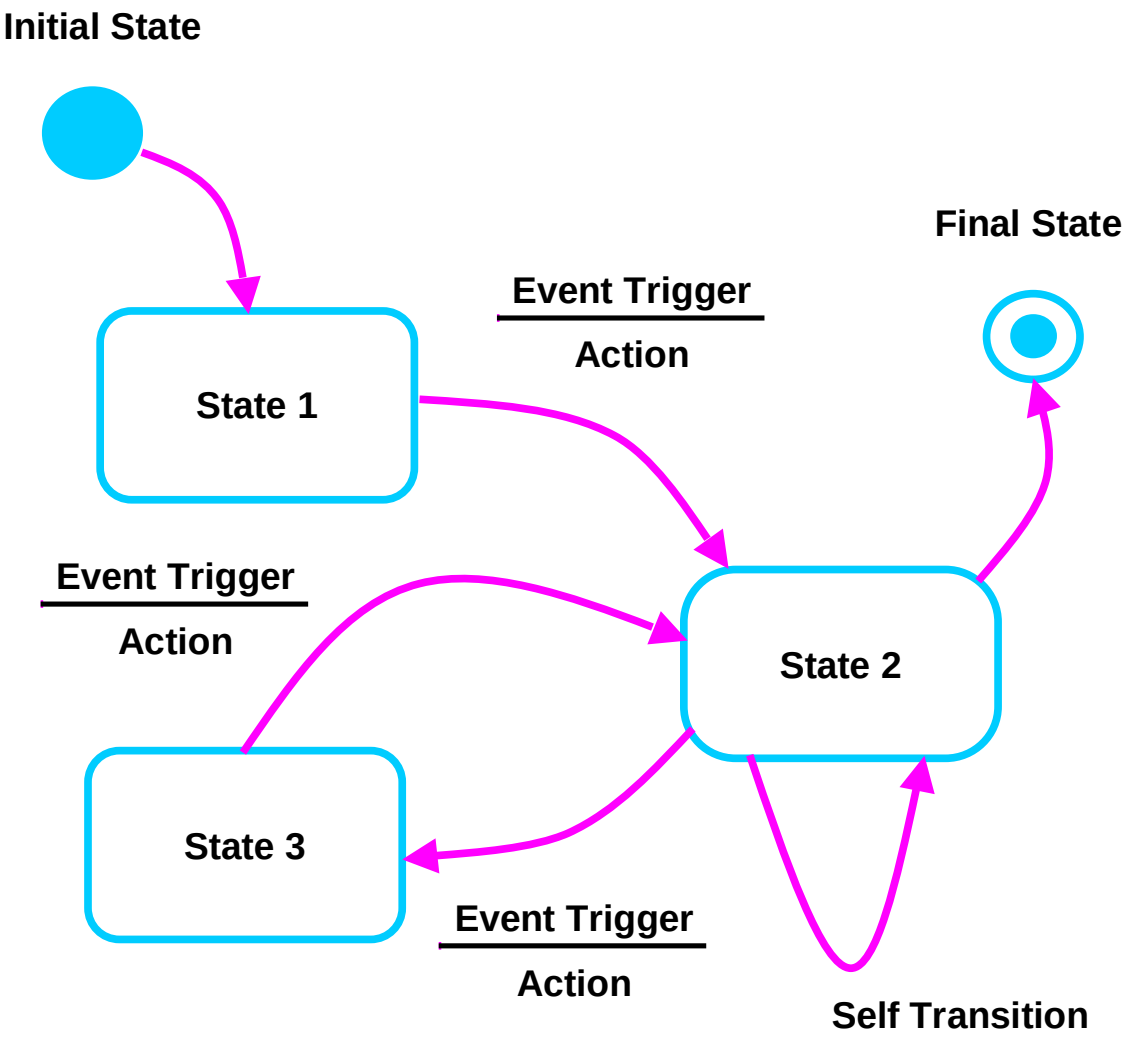


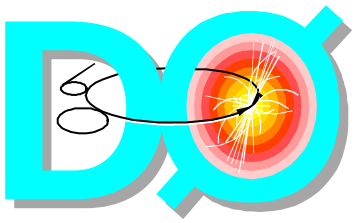
Definitions

- **Action**

  An *action* is an executable, atomic (with reference to the state machine) computation. Actions may include operations, the creation or destruction of other objects, or the sending of signals to other objects (events).

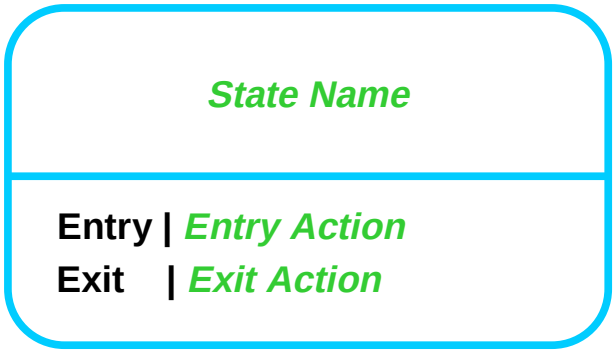
A Simple State Machine

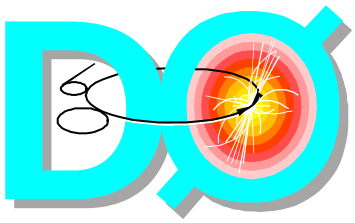




Advanced States

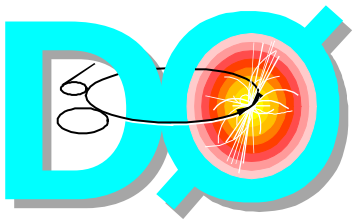
Entry and Exit Actions





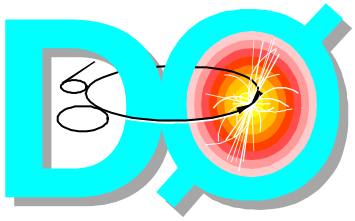
Definitions

- Substates
  - A ***substate*** is a state that is nested in another state
  - A state that has substates is called a ***composite state***
  - A state that has no substates is called a ***simple state***
  - Substates may be nested to any level



Advanced Transitions

- Transitions to a composite state
  - If a transition is to a composite state, the nested state machine must have an initial state
  - If a transition is to a substate, the substate is entered after any entry action for the enclosing composite state is executed followed by any entry action for the substate

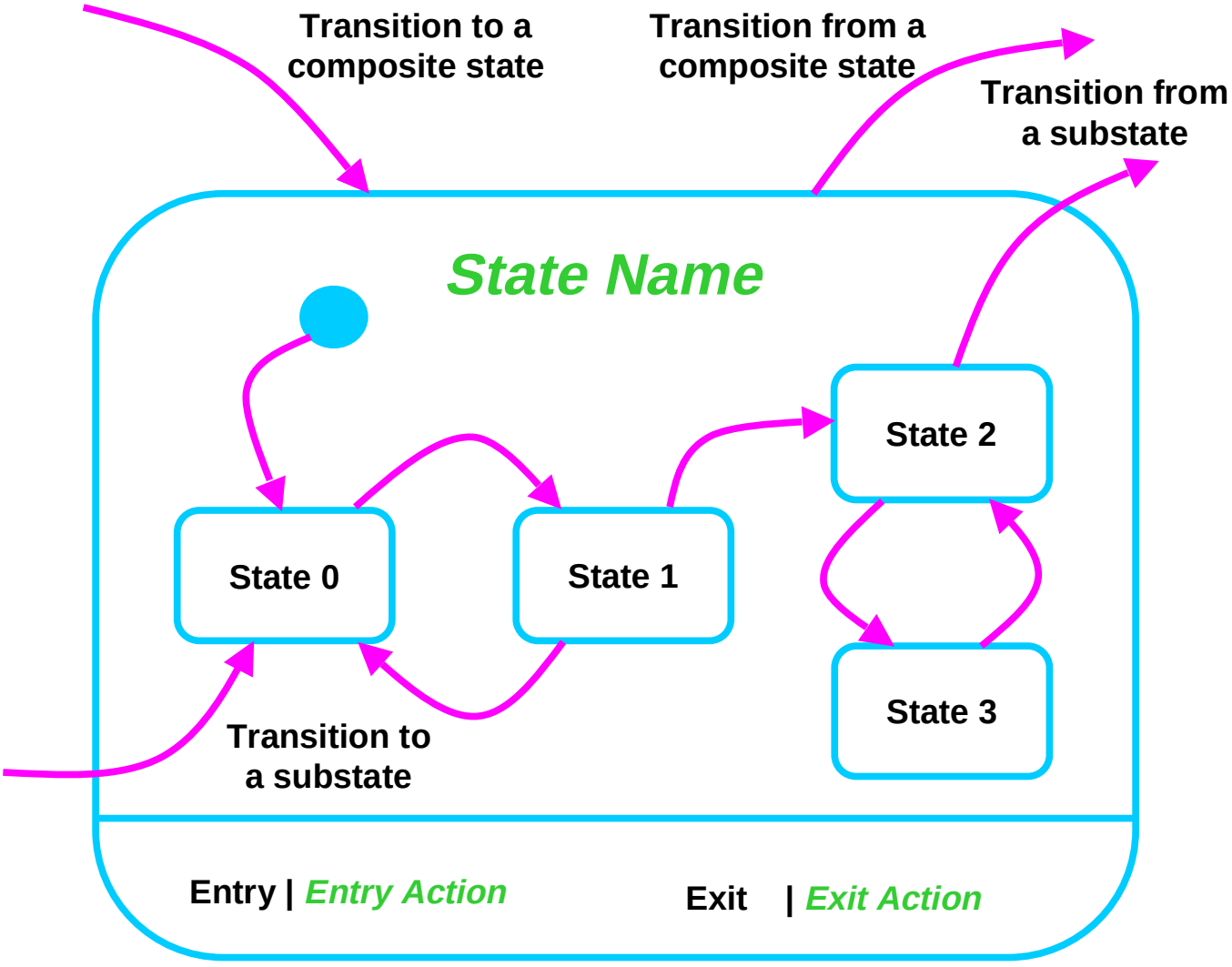


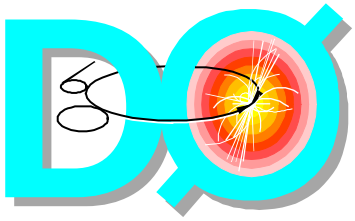
Advanced Transitions

- Transitions from a composite state
  - If a transition is from a substate within the composite state, any exit action for the substate is executed followed by any exit action for the enclosing composite state
  - A transition from the composite state may occur from any of the substates and takes precedence over any of the transitions for the current substate

Advanced State Machine

Sub-States





An Implementation

State Table

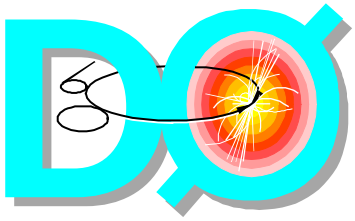
State

State	FirstIndex	LastIndex	EntryAction	ExitAction
0	0	1	Act1	Act2
1	2	2	None	Act3
2	3	4	None	None

Transition Table

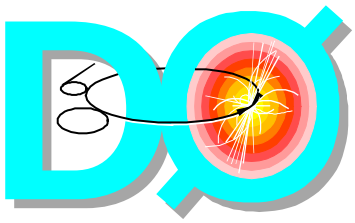
Index

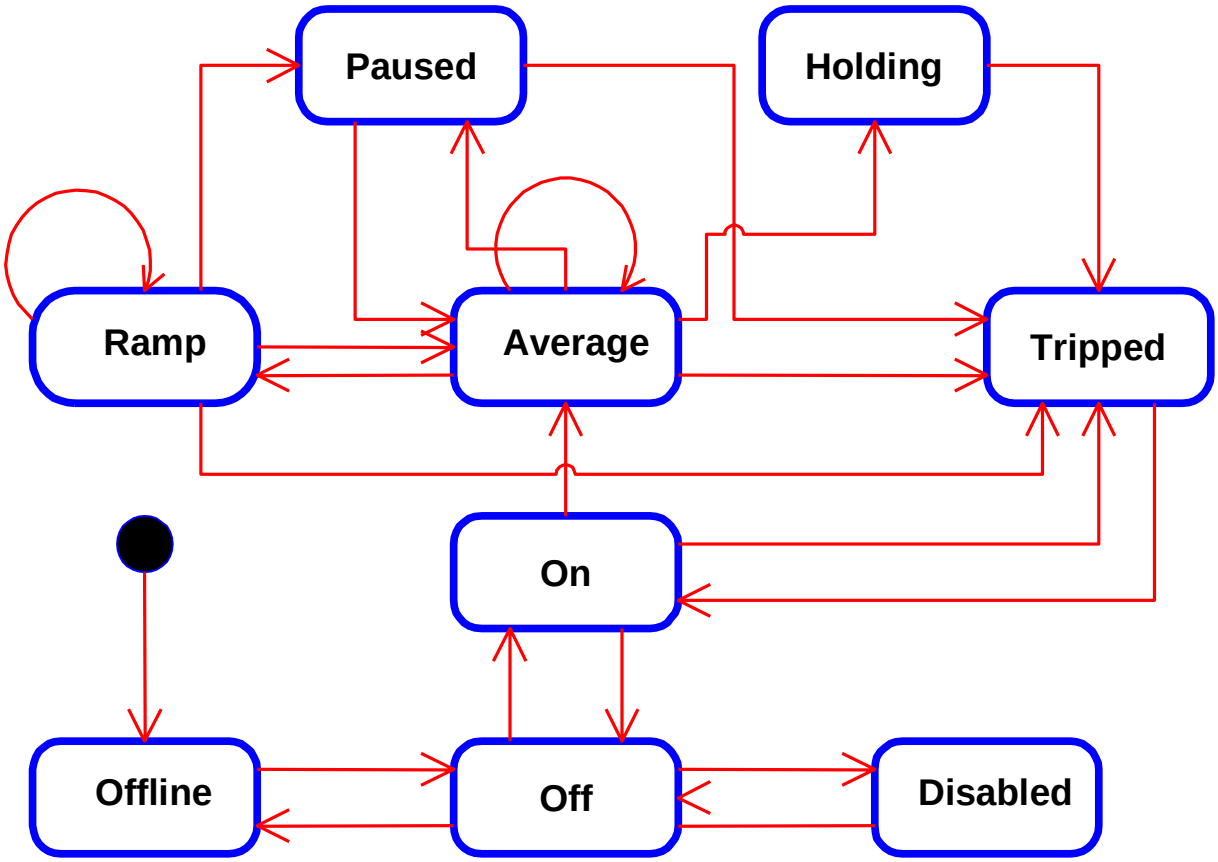
Trans	Events	Mask	Action	NewState
1	E0 & E1	E0 | E1	Act0	1
2	E1	E1 | E2	None	2
3	*	*	*	*



An Implementation

```
/*+

  MODULE stateMachine - Sequential State Machine Package Declarations

  DESCRIPTION:
    The stateMachine.h header file contains definitions of external
    interfaces to the state machine package
-*/

#define ssmMask(event) (1<<event)

  enum {SSM_TERMINAL_INDEX = (unsigned short int)-1};
  enum {SSM_NULL_ACTION = NULL};
  enum {SSM_MAX_EVENT = 31};

  typedef void *SsmId_t;

  typedef int (*SsmAction_t)(const SsmId_t stateId, void const *context,
                       const unsigned short int action);
  typedef void (*SsmDisplay_t)(char *text);
  typedef unsigned long int SsmEventSet_t;

  /* State table element */

  typedef struct
    {
    unsigned short int firstIndex;  /* First index in transition table */
    unsigned short int lastIndex;   /* Last index in transition table */
    unsigned short int inAction;    /* Entry action index */
    unsigned short int outAction;   /* Exit action index */
    } SsmState_t;

  /* Transition table element */

  typedef struct
    {
    SsmEventSet_t events;          /* Event value */
    SsmEventSet_t mask;            /* Event mask */
    unsigned short int action;     /* Action index */
    unsigned short int newState;   /* New state */
    } SsmTransition_t;

  extern SsmId_t ssmCreate(const unsigned short int initState,
                      const unsigned short int termState,
                      const unsigned short int maxIndex,
                      const SsmEventSet_t initEvents,
                      const SsmAction_t actionFunct,
                      void const *context,
                      SsmState_t (*stateTable)[],
                      SsmTransition_t (*transTable)[]);
  extern int ssmDelete(const SsmId_t stateId);
  extern int ssmEventClear(const SsmId_t stateId,
                      const unsigned int event);
  extern int ssmEventSet(const SsmId_t stateId,
                      const unsigned int event);
  extern unsigned int ssmExecute(const SsmId_t stateId);
  extern unsigned short int ssmCurStateGet(const SsmId_t stateId);
```



- **Problems with UML notation**
  - **When more than one transition from a state is enabled there is no method for specifying precedence**
  - **For nested states there is no method for specifying precedence of the enclosing or enclosed state**

Example: High Voltage Channel